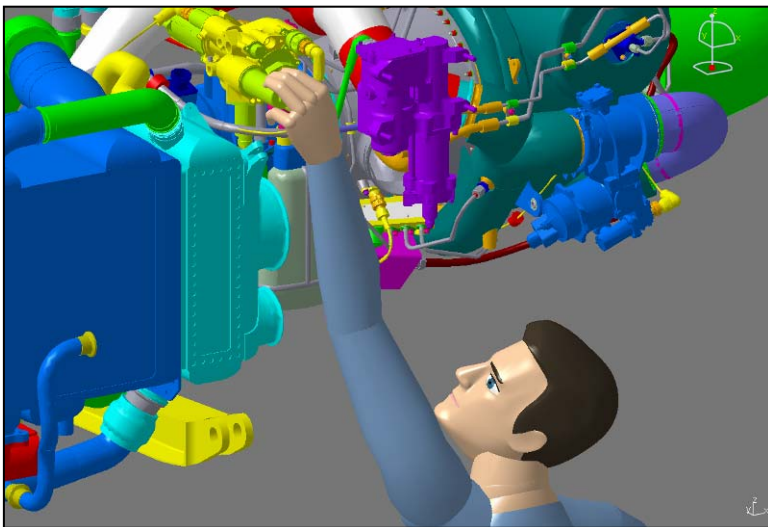


**AIRPLANE MAINTENANCE SIMULATION  
ANALYSIS- SAFER AND MORE EFFICIENT  
MANUFACTURING PROCESSES**

## Airplane Maintenance Simulation Analysis -Safer and More Efficient Manufacturing Processes

A leading aircraft manufacturer turned to Applied Manufacturing Technologies, Inc. (AMT) to use their simulation and process consulting expertise to identify issues and recommend solutions for service and maintenance operations on the manufacturer's airplanes. They asked AMT to perform service analyses on four specific maintenance operations with special consideration to ergonomic impact. AMT chose to use DELMIA V5 Software to do the analysis. DELMIA, a subsidiary of Dassault Systèmes, offers a comprehensive suite of digital manufacturing software that streamlines manufacturing processes to bring products to market faster as well as lowering manufacturing costs and encouraging innovation.



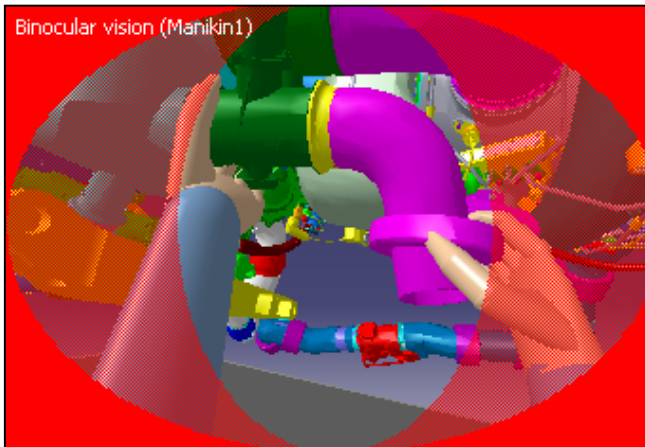
Manikin Reaching to Adjust a Valve

In essence, the customer needed to see four simulations that provided accurate confirmation that a given set of parts on an aircraft would be field serviceable and ergonomically compliant. If the parts could not easily be accessed, it would mean the expensive and time consuming removal of an entire sub-system. The benefits in time, money and safety involved in having the aircraft be field serviceable becomes even more obvious when you consider that in order to perform such a major repair, the aircraft would need to be moved to a fully equipped repair site, thus removing it from whatever theater of operation it was assigned to serve.

### **Part Selection**

The software used for the analyses was a DELMIA V5 simulation package using a human model or "manikin". AMT was given a list of parts on the aircraft in need of servicing. From this list, AMT was to create simulations that showed the removal of four of these parts. The parts

chosen for the test bed were the oil filter, thermocouple, fuel atomizer and fuel filter. If any of the parts proved to be unreachable, the turbo machine subsystem itself could also be virtually removed to determine what it takes to perform the maintenance operations. The parts were selected because of their proximity to the boundaries of the simulated airframe access panel; appearing to be the hardest to reach and thus providing the most beneficial results.



Manikin's View of the Workcell

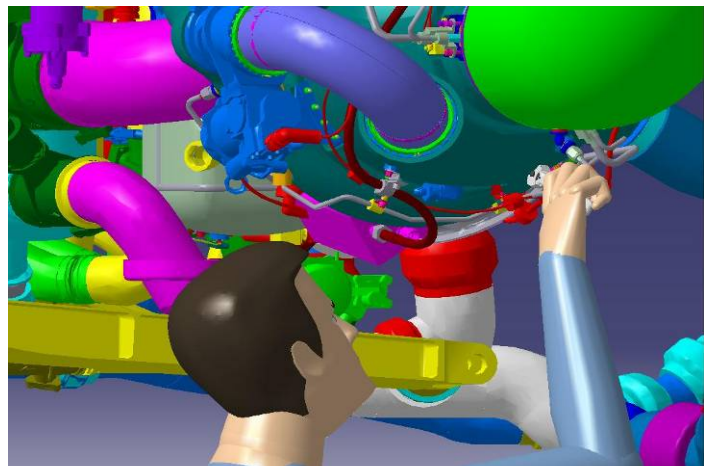
### Simulation Creation

When creating the simulation, AMT had to determine which tools the manikin would be allowed to use. Tool selection was restricted to a standard tool set (i.e. wrenches, screw drivers, pliers, sockets, etc.). No specialty tools were used.

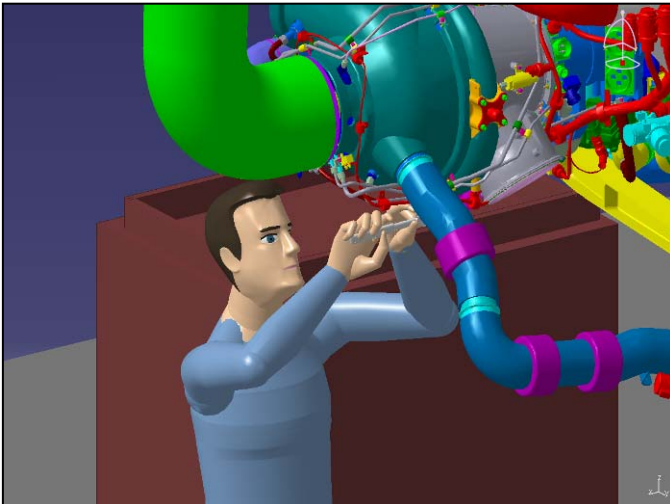
The simulations were to show a repair sequence/process for the various components chosen. For example, to access the thermocouple, a number of other components would need to be removed first. Not all the other components were identified

by name in the data that was provided to AMT. However, the visual fidelity provided by the software supports the assumption that any component would be recognized by someone familiar with the turbomachine and its maintenance. This further enhances the usability of the simulation by allowing it to be used as a visual training aid.

Additionally, the simulations were to provide ergonomic data regarding visibility and reach-ability. DELMIA's V5 software allows for the simulation's end-user to see exactly what the real life operator would see at any given point in the process. This feature proved its worth in making sure that the operator could easily see the location in which the repair was being made.



Manikin Performing Repairs



Manikin Performing Repairs

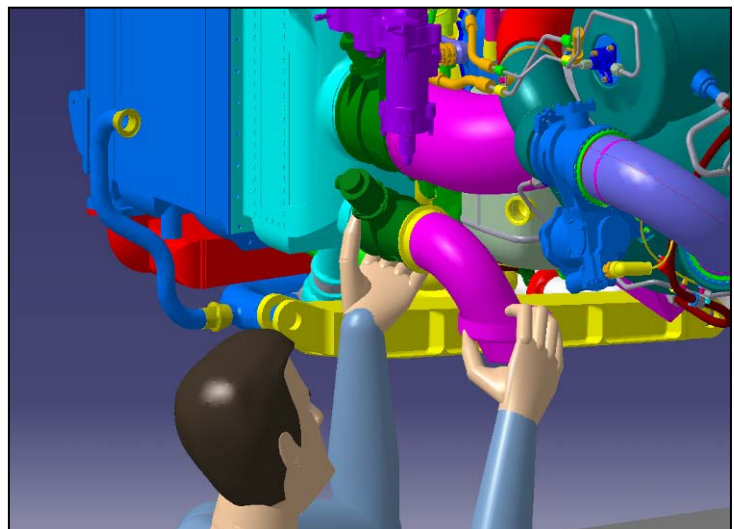
### Challenges

Most of the challenges encountered by AMT during the simulation process dealt with hand clearance and visibility. The most difficult case proved to be the wiring harness. Designing a single wire harness for use on the turbomachine reduces the overall complexity of the system. However, this requires that the harness be wrapped almost entirely around the turbomachine, which forces the manikin to reach deep into the airframe, reducing the hand/tool clearance and interfering with the operator's visibility. Consequentially, the operator is forced to adopt unusual

postures to compensate for the restricted access. At one point, the 50th percentile male manikin used had to stand on the balls of his feet to achieve an ergonomically acceptable hand position during certain portions of the wire harness removal process. In some instances, removal of components that were restricting access relieved the clearance problems and at other times switching to a deep well socket was the simplest solution. Since this simulation was being built to ensure ergonomic compliance and produce a repair process, removal of any necessary component was within the project specifications.

### Results

In all but one of the simulations, it was proved that the operator could access the parts without removing the entire turbomachine. Only certain portions of the wire harness proved inaccessible. In this case, AMT recommended that the turbomachine be removed. Posture analysis (ensuring that any given posture was ergonomically acceptable) was limited because these motions were not repetitive in nature like those encountered



Manikin Removing a Part for Repair

in an assembly line situation. If they had been repetitive, DELMIA's V5 software provides powerful tools to AMT's simulators to analyze postures based on loading and repetition frequency. In either case, making certain that people are not forced to adopt ergonomically incorrect postures due to poor design benefits both the employer and the employee. Reductions in healthcare cost from fewer stress injuries and short-term disability save companies' money while a more comfortable work environment increases worker morale and productivity. Additionally, manufacturers need to take into consideration design for manufacture (DFM) and design for disassembly (DFD) when determining product designs. For DFM, if the manufacturer can limit the number of parts needed, or even the tools necessary, then the process of assembling/disassembling the parts becomes much easier. This is very similar to DFD. DFD is the use of assembly methods and configurations that allow for cost-effective separation and recovery of reusable components and materials. This also takes into consideration maintenance operations. If the manufacturer can design a product with maintenance and disassembly in mind, then issues during maintenance such as hand clearance, reaches, and grasps may not arise in the future.

Applied Manufacturing Technologies- website: [www.appliedmfg.com](http://www.appliedmfg.com), email: [marketing@appliedmfg.com](mailto:marketing@appliedmfg.com), phone: 248-409-2000