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Reducing the Design-to-Manufacturing Cycle for the Great American Supercar

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Designing the Great American Supercar

With the assistance of a measuring system, photogrammetry and optical scanning, Ford was able to reduce its design-to-manufacturing cycle for the new Ford GT40 concept car.

Sherry L. Baranek

It was in France in the mid-1960s that the great American supercar came to life. A low-slung, muscular racing car built to win on the legendary Le Mans race circuit, the Ford GT40 project was spearheaded by Chairman and CEO Henry Ford II. His goal was to change performance car history — and he did. The Ford GT40 car beat the world's best in endurance racing, placing first, second and third at the 24 Hours of Le Mans in 1966 and winning the next three consecutive years.

Ford's new GT40 concept car was created to celebrate that great era in history and to look forward to the future. Unveiled at the 2002 North American International Auto Show, the Ford GT40 concept car became an instant sensation and just 45 days after the vehicle was unveiled, Ford stunned the world again by officially announcing that a production version was in the works.

"The Ford GT car is the ultimate Living Legend," explains J Mays, Ford vice president of design. "It's a true supercar with an appeal that is equal to that of the greatest sports cars in the world, but with the addition of a heritage nobody can match. Essential elements of the original — including the stunning low profile and mid-mounted American V-8 — are incorporated into this latest interpretation of the classic."

Figures courtesy of Ford Motor Company.

Figure 1 Camilo Pardo working on the design in clay.

The New Concept

Camilo Pardo has drawn and re-drawn the GT40 concept car design in his mind for more than 10 years. Even when he was given permission to do an exploratory clay model of a modern Ford GT40 concept car in 1999, he never really expected to create a fully developed concept car. The call that began the dream assignment of a lifetime

The technology and process provided by Capture 3D is being used in various forms at many time-compression driven organizations such as NASA, Boeing, DaimlerChrysler, Toyota, Nissan, Cessna, Walt Disney and Pratt Whitney.

came in March 2001, and Pardo was quick to begin work. As chief designer in Ford Motor Company's Living Legends Studio, Pardo led the design and development of the timeless Ford GT40 concept car.

While the new concept and the original Ford GT40 car share a common heritage, they do not share a single dimension. The concept is more than 18 inches longer and stands nearly four inches taller. Its new lines draw upon and refine the best features of the Ford GT40 history and express the car's identity through modern proportion and surface development.

The Automotive Design Process

Automotive design is very much an iterative process that typically takes years from initial design concept to final design to the manufacturing process. With the assistance of **Capture 3D** (Costa Mesa, CA; Livonia, MI) — the provider of Atos scanning systems in North America, with services focused on turning physical models into digital data and comprehensive inspection of tools and parts — and **GOM mbH** (Braunschweig, Germany) — the developers and manufacturers of the Atos and Tritop optical-based measurement systems — Ford was able to reduce its design-to-manufacturing cycle.

During the past four years, Capture 3D has provided an important part of the design process to Ford through the Atos and Tritop 3-D measuring systems, which were developed by GOM GmbH and used in areas such as balancing model designs, packaging studies, and die design and repair, as well as die spring-back analysis and tool building. With the launch of the Ford GT40 concept car project, Ford once again turned to this Structured Light technology to capture the numerous design iterations of the Ford GT40 concept car.

Initially, two separate versions of the new Ford GT40 concept car were designed and sculpted in clay. For the next four months continual design enhancements were made to the models in order to modernize the design yet maintain the original Ford GT40 car's concept and sensation.

Measuring Systems

Traditionally, large touch probe measuring systems were used to try to capture the design intent. This process could take several days and only provide cross-sectional data, which oftentimes left out much of the details. These cross-sections were then used to develop surfaces. A toolpath would then be developed from the surface and the second half of the clay model would be milled — called "balancing" the model. From the initial measuring to the final milling, this was typically a three-week process **(see Figure 1)**.

With the implementation of the Atos scanning system, Ford has been able to reduce that cycle to three days. There are three elements that are instrumental in producing this timesavings:

(1) The speed at which data is acquired. Traditional methods are slow and tedious — taking up to three days to measure a full-size car. With the Atos scanning system, Ford is able to scan a full-size vehicle in a day.

(2) The most significant element is that with the ability to capture 1.3 million points in seven seconds, the complete model can be measured efficiently and accurately, capturing even very small details. Now the true design intent of the designer can be captured without any misinterpretation.

(3) Capturing so much information leads to the third element. Ford is now able to accurately and with full detail create a polygonal mesh of the model. Traditional methods required creating surfaces from measured data and from these surfaces CAD/CAM packages would generate the toolpath for milling. With the ability to generate an extremely high quality mesh, Ford is able to generate a toolpath and "balance" the model without creating a surface model. This process that used to take about three weeks now takes about three days **(see Figures 2a and 2b)**.

A model of the Ford GT40 concept car ended up at Harvard University in a display for innovation and design by J Mays, the vice president of design at Ford Motor Company. Ford contacted Capture 3D to travel to Massachusetts to gather data on the vehicle.

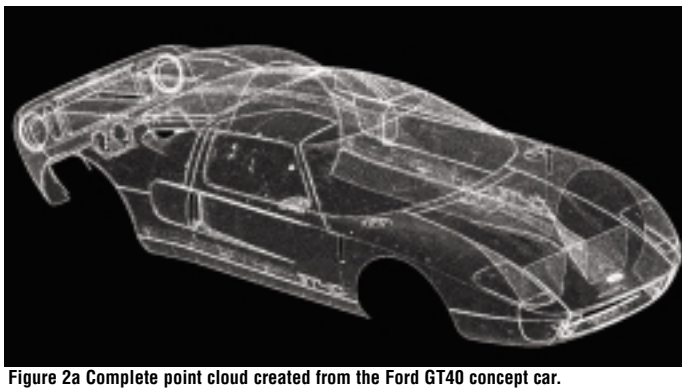

Figure 2a Complete point cloud created from the Ford GT40 concept car.

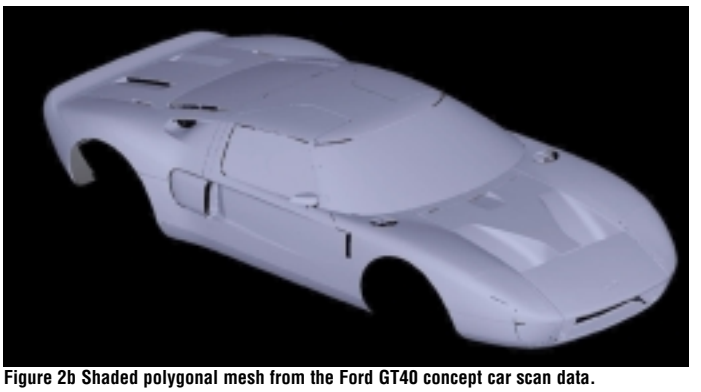

Figure 2b Shaded polygonal mesh from the Ford GT40 concept car scan data.

There was only a short timeframe when the display would be closed, allowing access to the model. So on February 17th, Capture 3D traveled to Harvard to repeat the process that had already been repeated so many times by Ford. As is the case for measuring objects of this size and larger, there are two steps in the measurement process — photogrammetry and scanning.

Collecting 3-D Data

The process of obtaining complete 3-D data on the Ford GT40 concept car involved a two-step process: photogrammetry and optical scanning. The photogrammetry process establishes proper coordinate position and a reference grid right on the model itself while the optical scanning process captures the detailed surface data of the model and aligns each patch based on the reference grid produced from photogrammetry.

Photogrammetry

Photogrammetry is a well-known technology in the aerospace industry and has been used for years as an inspection tool for

Figure 3 Ford GT40 concept car set up for photogrammetry.

Figure 4a The scanning process of the Ford GT40 concept car.

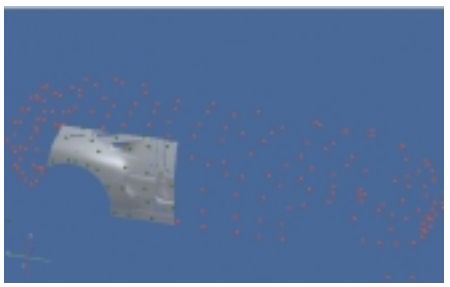

Figure 4b Resultant scan patches with photogrammetric reference.

aircraft and other large components because of its accuracy over large measuring areas. The photogrammetry system used for the GT40 concept car project was the Tritop system provided by Capture 3D and developed by GOM mbH.

The photogrammetry process measures small circular targets printed out on adhesive paper, which creates a reference system right on the model that provides overall dimensional data and the facility to align each section scanned to the proper coordinate position.

Because of the Ford GT40 concept car's size, targets with a diameter size of 8.0 mm were chosen. For smaller objects, smaller targets are used. The targets were placed roughly in a grid pattern with approximately 24-inch spacing between each target in each direction. There is no requirement for accuracy in placement of the targets. The idea is to place them in such a way that the Atos scanner can see at least three targets in its field of view during the scanning process. The specific Atos system used was set up to have a measuring volume of 800 mm x 640 mm x 640 mm (32" x 27" x 27").

After placing the circular targets, coded targets were placed around the model with a spacing of approximately three feet in each direction. Coded targets all have a unique shape, which can be identified by the computer. These targets are used to match all of the images taken from the digital camera **(see Figure 3)**. The photogrammetry process uses a very high-resolution digital camera that requires a standoff distance, which is proportional to the size of the part being measured.

Scanning

The next step in the process is to use the Atos II scanning system to capture the actual surface details of the model. The system itself has the ability to change the measuring volume to accommodate various part and feature sizes. The system captures 1.3 million points in a seven-second period and can cover an area from 50 mm x 40 mm up to 1,200 mm x 900 mm. The smaller measuring volumes result in the points being closer together and capturing greater detail. For the purpose of the Ford GT40 concept car scan, a measuring volume of 800 mm x 640 mm was used, which provides a point every 0.6 mm.

The Atos II uses a dual-camera sensor with a highly optimized structured light projection unit. The system is based on fringe projection, triangulation and phase shifting — producing very accurate "point cloud" data representing the surface of the model. Measuring each section takes about seven seconds. That section is then automatically transformed into the correct body coordinate position based upon the target reference information from the photogrammetry process. As long as three reference targets are captured in each view, the system has the information to align the sections together **(see Figures 4a and 4b)**. The sensor is provided on a stand that can be moved around the object freely in order to obtain all of the different views to capture the required geometry.

The data resulting from this system is essentially a very accurate 3-D measurement of the model at that point in time.

Summary

Brian Bowman, manager of design, milling and measurement at Ford Motor Company, began implementing this technology four years ago. Throughout that period the applications have been consistently growing. Ford is currently scanning about 120 jobs per month, 26 of those are typically full-size cars.

"We have seen a 90 percent increase in our digitizing throughput by implementing the Atos scanning technology into our process," says Bowman. "The data resulting from this system is essentially a very accurate 3-D measurement of the model at that point in time. If the design team wants to revert to a previous iteration of the model to explore a different design theme, we can produce CNC programs directly from the scan data and use a mill to recreate the model. This technology has enabled our designers to make quick, decisive changes." Bowman goes onto to say, "It has been one of the most significant productivity enhancements for our department during the past eight years."

This process is becoming increasingly more common for both the development of CAD/CAM models from physical parts, as well as the inspection of manufactured parts to the design intent. The technology and process provided by Capture 3D is being used in various forms at many time-compression driven organizations such as NASA, Boeing, DaimlerChrysler, Toyota, Nissan, Cessna, Walt Disney and Pratt Whitney.

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*For more information contact **Capture 3D Incorporated** at (714) 546-7072 or via its website at www.capture3d.com.*