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Digital-measuring arm helps vehicle simulator find "right feel" in new designs

Prefix Corporation has developed a Programmable Vehicle Model (PVM) that can emulate the cab of hundreds of different vehicles. They use a FaroArm digital measuring system to verify and create a record of the driver-to-component layout.

By Fred Bryson

The ergonomics of the drivers' environment has emerged as a crucial competitive factor in vehicle design. To the prospective owner who tries out current models from one dealership to another, small changes in the location of controls, parking brake location, seat position, seat contour, and instrument panel position often tip the scale in favor of one car over another. When the new owner makes the all-important choice, he buys what feels right to him. To help automotive development engineers capture "the right feel," one Michigan-based company uses a computerized measuring device known as the FaroArm to confirm the ergonomics.

Flexible simulator

A carmaker's quest for an ergonomic edge in a vehicle begins early in its modeling stages. Prefix Corporation of Rochester Hills, MI, developed and patented an adjustable prototype development device called a Programmable Vehicle Model (PVM). PVMs enable carmakers to emulate the in-cab spatial relations and layout of the vehicles that they intend to build-as well as those of competitors' cars. The FaroArm allows Prefix to create a record of the interior package in CAD drawing form for both future reference and presentation purposes.

"Setting the buck"

PVMs evolved from the static design models of interiors (known as seating "bucks") that automakers used for decades prior to the early 1990s. To the eye, PVMs look like a vehicle. However, underneath the interior and exterior surfaces exists a precision computer controlled electromechanical machine.

A PVM is a machine outfitted inside and out (at the customer's request) to appear like a vehicle. Each functional element (seat, roof pillar, steering wheel, etc.) can be moved to emulate different trial designs within ±½ millimeter. Meanwhile the positions of all the elements are monitored and updated within Prefix's PVM control software. Individual elements are mounted on THK bearing rails using ball screws to move them, via stepper motors, in two or three dimensions. Thus, the spatial relationships of, say, the seat to the instrument panel can be adjusted so that visibility or knee room can be changed. Complex PVMs can use up to 96 individual motors, although typical ones use 70-75 motors. All are controlled by Prefix's patented PVM computer controller.

Prefix builds two primary types of PVMs for carmakers: flexible and near final, and most carmakers use both types, in sequence, during the process of development. The flexible type is for early development; they are less realistic, but are suited to making gross changes in vehicle interior size and layout. The near-final type looks much like the vehicle that is being developed. Instrument and door panels may be outfitted with the final surfaces-but it is less adjustable than the flexible units. For instance, roof pillars of the flexible model are straight pieces that are adjustable over a range of approximately 8 inches. On the near-final model, roof pillars are swept aerodynamically, but can only be adjusted only about 2 inches.

Prefix implements FaroArm

Figure 1: Components of Programmable Vehicle Model (PVM) include computer/controller that drives components of the PVM into various positions. Technician checks final position of components with FaroArm.

Figure 2: Technician measures headroom with FaroArm on Prefix PVM. Weights compress seat cushions to simulate that caused by a driver's body weight.

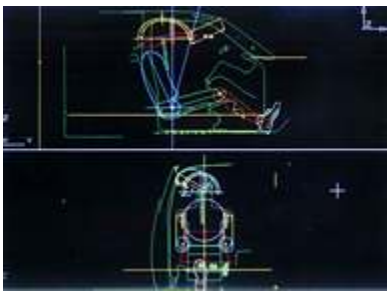

Figure 3: Measured coordinates taken from specific PVM configurations appear on the screen of the computer used with the FaroArm, in real time.

Using human test drivers and the S.A.E manikin an automaker goes through an exhaustive process to determine what combinations of positions for seat, steering wheel, roof, and instrument panel feel best. Because the parts are movable-some in three dimensions-the choices are almost limitless. This is a process of trial and error, one in which small changes in position can mean large subjective changes for test drivers.

Using the static seating bucks a change would oftentimes require a complete rework which was very time consuming and costly. Now, using the more versatile PVMs, the best layout is determined much more quickly because changes can be made electronically in a matter of seconds. At this point, the "interior package is set" and the interior design is passed on to manufacturing.

Capturing incremental improvements

In the process of setting the buck, incremental improvements in the ergonomics represent progress. Should an element be positioned 5 millimeters to the left or 5 millimeters higher . . . or both? Once the best position of the element is determined, the team can turn to other elements, to fine-tune the ergonomics of the interior package.

At this point of the process the FaroArm becomes useful. Prefix uses the FaroArm to scan the previously positioned interior in order to create a drawing of the desired interior package. The 8-ft arm used by Prefix is one of a family of portable measuring arms, developed by FARO Technologies of Lake Mary, FL. It is a counterbalanced, articulating mechanical system, with joints formed by rotational transducers that determine the X-Y-Z location and I-J-K orientation of a probe stylus at the end of the arm. With six or seven degrees of freedom, the arm can measure the 3-D shape of any solid object, and can even reach around and under objects where necessary. To measure the distance between two objects, a Prefix operator simply touches the part at the desired location with the stylus and presses a button on the handle, then touches the arm to the other part and presses the button again. Instantly, the relative locations of the items are digitally captured by the arm. Additionally, entire surfaces and their relative proximities to each other can be measured.

Measurements taken with the FaroArm are precise; for the 8-ft Silver model used by Prefix, the 2 Sigma single point accuracy is ±0.003 in., as certified by ANSI B89 standards. The arm is portable, too. Weighing only 30 pounds, it can be moved from one PVM to another easily.

Software to reestablish configurations

Not only does the arm measure the locations and surfaces, it remembers them. As it is moved by an operator from one point in the PVM to another, the transducers transmit the changes to a host computer, usually a laptop. Resident in the computer at Prefix is a unique measuring program known as AnthroCAM software. This is a 3-D CAD-based measurement, reverse engineering, and analysis software developed by FARO.

As the operator continues to move the arm and take additional points, the software "builds" a 3-D CAD file, in real time. Once this file is developed the distances between such things as the S.A.E. manikin's H-point and its heel point or height difference between the instrument cluster binnacle and the windshield touch down point can be measured. Additionally, the 3-D CAD drawings derived from the FaroArm allow Prefix to place a CAD version of the S.A.E manikin including head template into the vehicle. By this method lateral and diagonal head clearances previously measured using an actual Prefix developed S.A.E manikin head template can be verified in 2-D. These CAD files also serve as an excellent presentation resource.

This combination of measuring and prototyping equipment enables Prefix to compare the dimensions of competitive vehicles to the one on which they are working. “We can dimensionally represent a vast number of vehicles and yet keep the design of the instrument panel, headliner, door panels, seats, etc. constant. This allows people to objectively judge the overall roominess of a variety of interior packages while keeping the other elements constant,” Kurt Zeile of Prefix explained.

“Mirror image” engineering and other uses

Figure 4: Technician taking surface measurements on clay model with FaroArm. Image of surface is "built" in the computer, then flipped to produce the mirror image part. Thus, by developing an image of a model's right fender, Prefix can quickly create the image of the mirror image left fender.

AnthroCAM software enables users of the FaroArm not only to measure and inspect physical objects; it helps them to recreate them as well. A number of aircraft, automotive, and metal-forming customers use the FaroArm and AnthroCAM software to reverse engineer products for which no drawings exist.

At Prefix, they have an unusual application for the capacity for recreating parts. Prefix has a prototype vehicle modeling shop wherein they use the FARO system to speed up the production of full-scale models.

When their prototype team is building a model of a new vehicle, they work in clay that is supported by styrofoam. As one section—for instance, the left front fender—is complete, they measure it with the FaroArm and develop a digital image of the fender's surface. Then, in the AnthroCAM software, they flip the image so that it becomes a mirror image of the original-or right fender. Next, they print out the mirror image "sections" of the right fender on paper. These sections correspond to the thickness of the styrofoam sheets that they use in the modeling process. The paper printouts are then glued onto styrofoam and cut into the shapes of the sections. Finally, the sections are stacked and glued together to represent the right fender of the vehicle. "All we have to do is fill in the gaps between the sections with clay and smooth out the fender," said Zeile. "On any given model, this shortens our production time by an average of one man-week."

Thus, the versatility of the FaroArm and AnthroCAM software enables Prefix engineers to be highly creative in how they manipulate images in their prototype and modeling processes. As an added advantage, the portable measuring system enables them to trim substantial time from both areas.

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