



White Paper: Horizontal Modeling & Digital Process Design

Fresh Ideas Growing

Delphi Technologies, Inc.

Horizontal Modeling™ and Digital Process Design™ are patented CAD/CAM methodologies that significantly lower product and process design costs throughout the design-to-manufacturing cycle. These forward-thinking design techniques are industry-tested and proven to shorten design cycles and lead times, reduce waste, and dramatically accelerate time to market. In short, Delphi has invented new ways to innovate, faster and at lower cost!

Executive Summary

By changing the way designers create 3D CAD models with their existing CAD systems, the Horizontal Modeling (HM) methodology produces higher quality CAD data that are easier to change and much more usable in design and downstream functions. Using these “horizontal” models, the Digital Process Design (DPD) methodology enables the rapid creation of master process models and their associated process sheets, an otherwise hugely time-consuming task. Together, these methodologies enable controlled, instant design change propagation throughout the enterprise.

Manufacturers who implement these Delphi methodologies will realize greater concurrency between product design and manufacturing process design, while simultaneously compressing product and process cycle times. This results in immediate benefits to the whole manufacturing enterprise through increased productivity, reduced staff and resource requirements, and optimized utilization of existing capital equipment investments. Furthermore, designs that are easier to change and use enhance creativity and development of new ideas, leading to greater innovation. These methodologies have been implemented and proven at manufacturers worldwide, with large, measurable time and cost savings.

Product Design Activity	Productivity Improvement
CAD Operator Functions	Using HM & DPD ~15 Process Designers
(% of total time spent)	(% of total time spent)
Create Models 20%	→ 50% Reduction
Detail Drawings 30%	—
Edit Models 50%	→ 90% Reduction

Horizontal Modeling Methodology

Horizontal Modeling was invented and proven with real-world expertise by Delphi, a leading provider of high technology solutions, and one of the world’s leading automotive parts manufacturers. It is in production use today at over a dozen plants worldwide. All data provided in this document has been gathered through actual testing and production use of the HM methodology.

Horizontal Modeling provides a new, simplified approach to using existing 3D CAD systems in product design. The implementation of HM yields higher quality CAD models and eliminates the need to recreate CAD data throughout product and manufacturing process design cycles. The methodology allows designers to work from fewer CAD models, which streamlines the product design process, raising productivity, enabling faster updates and changes, and automating downstream flow of process documentation for

Driving Tomorrow's Technology
Driving Tomorrow's Technology

Key Benefits:

- Lower cost
- Faster time to release/market
- Shorter design cycles
- Increased lead times
- Increased productivity
- Greater innovation

manufacturing. Use of HM measurably lowers product and process design costs, while shortening design lead times, reducing waste, and boosting the efficiency of countless downstream applications – all resulting in higher productivity and faster time to market.

HM also improves data and design quality. By streamlining the design change process, more ideas can be tested at lower cost, which results in higher quality design concepts and less wasted material and time, within a naturally occurring “lean” design process. This squarely supports ongoing 6-Sigma quality initiatives.

Digital Process Design is one of many such downstream applications. Using DPD, manufacturing process models and their associated process drawings can be automatically created, updated and deployed, while the design data is used and managed more efficiently. This enables instant, automatic design change propagation without lengthy rework and delay in the design-to-manufacture cycle. Entire design-to-manufacture schedules become more concurrent and compressed, yielding greater efficiency, productivity and competitiveness for manufacturing enterprises.

Delphi has invented new ways to innovate — faster and at lower cost.

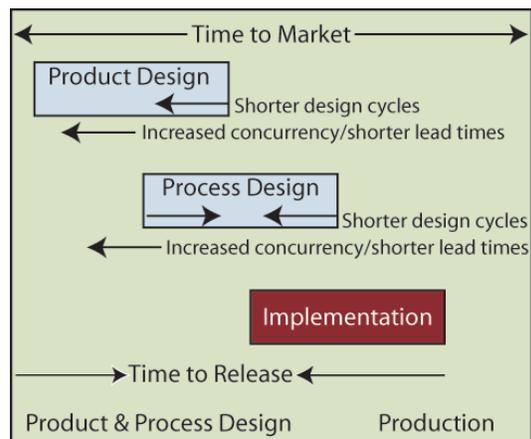
“We realized immediate benefits with Horizontal Modeling. Instant design change propagation measurably cut our costs while accelerating design-to-manufacture cycle times. HM and DPD have enabled a new level of innovation throughout our entire design operation.”
— Pete Janak, VP/CIO, Delphi

Positive Change of Design Methodology

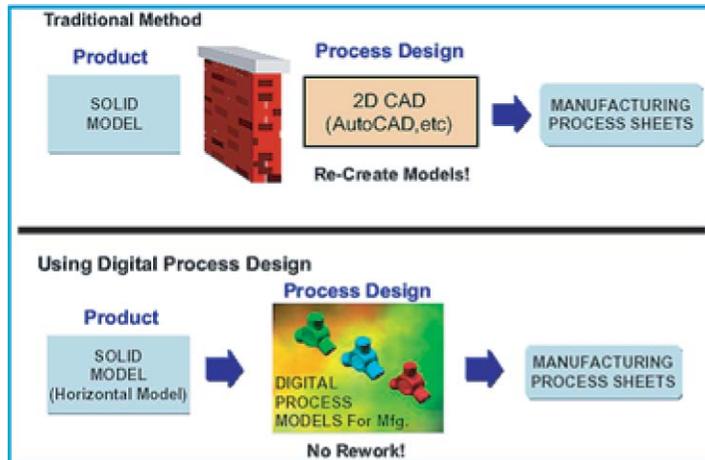
Horizontal Modeling brings a new approach to the way a 3D model is created using a CAD system. By breaking away from the traditional method of “vertically” feature-based design, Horizontal Modeling enables a new level of flexibility in design, detailing, creation, and editing of CAD data for enhanced downstream use.

Horizontal Modeling eliminates problems inherent in standard feature-based modeling strategies.

The ‘traditional’ method of feature-based modeling, as taught by major 3D CAD software vendors, stipulates the creation of vertical hierarchies of features with multiple, associated parent/child relationships between them. Simple changes to any or all of the features are usually



Shows the areas where HM and DPD enhance concurrency, shorten design cycles, and increase lead times to enable greater efficiency and productivity.



Comparison of traditional 2D methodology to Digital Process Design.

very complicated and often altogether prevented. Because of these parent/child relationships, CAD users and designers are often forced to dismantle the model to make the change, or recreate the model completely.

While feature-based modeling has advanced the art of computer-based design, it remains an imperfect approach due to these inherent limitations in “vertically” oriented modeling strategies. Feature-based modeling has failed to adequately address the need for rapid design change propagation in downstream applications and processes. For example, creation of manufacturing process models and process drawings from “vertical” feature-based models necessitates the creation of multiple, nearly redundant, non-associated process design documents. Each time an engineering change occurs, these unlinked process documents each have to be changed manually, wasting valuable time and resources.

Use of HM allows engineers to capture design intent without creating parent/child relationships, erasing the disadvantages caused by feature dependencies in product and manufacturing process design.

In conjunction with HM, the Digital Process Design methodology allows the rapid creation of manufacturing process documents that can be automatically changed through direct edits to a single ‘master’ process model.

Delphi is always looking for new, ever more efficient, and lean, processes and designs to meet customer demands. Prior to using DPD, Delphi found itself faced with inefficient design processes that were failing to meet the demands of ‘lean design’ during the production of manufacturing process drawings. As an example, the company would take finished 3D CAD designs, and create them in a 2D CAD system for manufacturing process design. This resulted in this new data being entirely disassociated from the original design, and then repeated across multiple process drawing sheet sets. This in turn created inefficiencies when an engineering change order was received – each document would need to be updated manually and closely cross-checked for accuracy.

Delphi searched for a solution that would link the original 3D design data automatically to the

Horizontal Modeling provides a new, simplified approach to using existing 3D CAD systems in product design.

creation of manufacturing process documents, but no adequate solution could be found from the CAD vendors. As a result, DPD, an application of Horizontal Modeling, provided the answer: DPD relates all manufacturing process documents directly from a single manufacturing process model. All changes made to the model are automatically and instantly propagated into each process drawing, eliminating the need for lengthy, tedious rework of each document, and reducing the time needed for checking and verification of the changed data. This eliminates the need to change multiple process models and drawings for each ECO, as required in many popular CAD systems. It also dramatically reduces the cost of process design and helps ensure optimized designs for manufacturing.

The HM and DPD methodologies are proven in the real-world as viable strategies for improving product and process design efficiency, in addition to streamlining downstream business workflows. Furthermore, these methodologies are already exhibiting similar effects throughout many other downstream applications that use and reuse CAD design data including analysis, prototyping, testing and machining. The following sections describe the business and workflow benefits accruing from the application of HM (for product design) and DPD (for process design) as they are being used at Delphi plants worldwide.

A reduction in required personnel produced a cost savings of \$2,420,000 on this design team alone in a single year.

Reduced Design Costs

Horizontal Modeling allows designers to rapidly update, edit and change 3D CAD designs without requiring costly rework, 'dismantling' of a 3D CAD model or, ultimately, creating new CAD data. One Delphi product team was staffed with 18 in-house CAD operators and 16-18 outside contractors for a design. Using HM, the next design required 14 in-house CAD designers, and no outside contractors, a reduction of 60%. If product designers cost \$110,000 per person-year (fully costed), this represents a cost savings of \$2,420,000 on this design team alone in a year. HM allows designers to take on more projects without increasing resources, eliminating outside contractors while handling their existing workload, and greatly increasing their overall productivity.

For Product Designers using HM, Delphi measured a 20% reduction in time for creating models and a 65% for editing models, compared to the traditional vertical modeling approach. (See chart below.)

Similarly, for Manufacturing Process Designers using HM and DPD, Delphi measured a 50% reduction in time for creating and 90% reduction in time for editing Process Drawings, compared to the traditional manual process using AutoCAD. (See chart on page 1.)

Product Design Activity	Productivity Improvement Using HM & DPD
CAD Operator Functions	~70 CAD Operators
(% of total time spent)	(% of total time spent)
Create Models 20%	→ 20% Reduction
Detail Drawings 30%	—
Edit Models 50%	→ 65% Reduction

Business Benefits of HM & DPD In the Design and Process Cycles

With HM, manufacturers experience significant bottom-line benefits, including:

- Lower product and process design costs
- Accelerated time to release/market
- Shortened design cycles
- Increased lead times

In addition, they experience additional financial top-line benefits, including:

- Increased productivity of design resources
- Reduced resource requirements
- Greater innovative freedom
- Increased competitiveness
- Increased ROI on existing CAD/IT investments

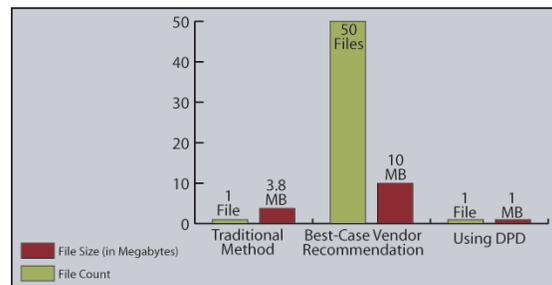
Shorter Lead Times

Delphi designers and engineers also measured noticeably shorter time-to-release for the product designs into manufacturing. By enhancing concurrency between product and process design phases, they measured a 50% reduction in process drawing creation time, which reduced lead times three to four-fold, while completely eliminating costly detailing work.

Less Wasted Time & Material

The improved data quality and structured HM and DPD methodologies also contributed to Delphi's pursuit of lean design and 6-Sigma quality manufacturing practices. During testing and implementation throughout Delphi, it was found that all product designs created using HM were 100% usable in downstream applications. Prior to implementation, a model was typically only 0% to 10% usable – 90% to 100% of the data typically had to be recreated manually. The HM methodology Delphi delivered a 76% reduction in model detailing and process model creation costs, consistently throughout the organization. In addition, time required to create process drawings was reduced by 80% to 90%.

Before HM, every designer had his/her own way of doing things, making it difficult for a designer to get up to speed on CAD files created by another designer. Now, because everyone uses the same HM methodology, up to speed time is virtually eliminated, design intent and details are already understood, and changes can be made very quickly. This lets people move around to different projects more easily, providing much greater flexibility in staffing.



The reduction in data file counts and sizes using HM versus the traditional methods previously undertaken by Delphi.

Horizontally modeled features enable rapid changes to any and all features in the model without the need for arduous “dismantling” and rebuilding of the design.

By enhancing concurrency between product and process design phases, they measured a 50% reduction in process drawing creation time, which reduced lead times three- to four-fold.

Faster Time to Market

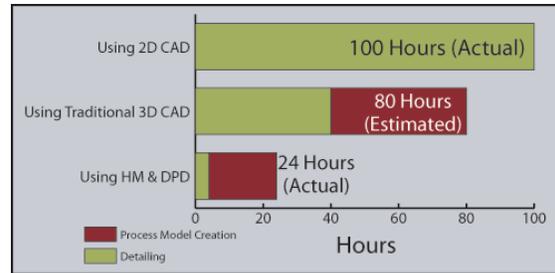
All business processes that use the HM/DPD methodologies result in each stage of design-to-manufacture being driven to greater efficiency, cost-effectiveness and with increased productivity. By centralizing the design data, and streamlining the creation and flow of the data as it is needed downstream, product release times were noticeably improved.

According to Dr. Nady Boules, Director of Delphi's Dynamics Innovation Center, "These methodologies have significantly reduced the cost of product and process design. Greater integration between design and manufacturing has resulted in a much shorter design to manufacture cycle, which yields a faster time to market for our products."

Improved ROI on Existing CAD/IT Investments

By reducing the staff and resource requirements by more than 50%, and because HM and DPD work on most popular 3D CAD systems, the methods reduce demand for CAD stations and operators per project. HM and DPD also work across a wide range of 3D CAD systems, magnifying this benefit. This enables Delphi to create more products in less time, while optimizing resource utilization. Delphi thus realizes a faster and higher return on their IT investments.

"In our highly competitive market, we recognize a critical need to continuously improve efficiency and productivity," explained Pete Janak, VP & CIO at Delphi. "Horizontal Modeling and Digital Process Design allows our product designers to measurably increase throughput and expedite CAD



Comparison of hours spent creating process drawings for Power Steering Housing using HM and DPD versus traditional techniques.

projects through application of improved IT capabilities."

Future Applications of Horizontal Modeling

It has been shown that the implementation of Delphi's Horizontal Modeling methodology results in significant increases in productivity, efficiency, and competitiveness for a manufacturing enterprise. Delphi has also shown that this methodology can be easily applied to other downstream applications.

Ongoing work and testing is underway for the application of HM into other strategic downstream operations, including rapid prototyping, CMM, NC Machining, and tooling & analysis. It is fully anticipated that implementation and usability of these applications will provide similarly significant increases in productivity and efficiency for manufacturers.

Greater integration between design and manufacturing has resulted in a shorter design-to-manufacture cycle.

Horizontal Modeling is in production use at over a dozen plants worldwide.

For More Information

Delphi Technologies, Inc., a subsidiary of Delphi Corporation (NYSE:DPH), is sharing Delphi's CAD/CAM methodologies with other manufacturers through licensing and training arrangements. For more information, please visit www.delphi.com/dti or contact Jeffrey Solash using the information below:

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Delphi Technologies, Inc.

DTI is the intellectual property arm of Delphi Corporation, a \$28 billion supplier of automotive electronics, transportation components, and integrated systems.

DTI's mission is to commercialize and license Delphi's intellectual property, with an emphasis on opportunities outside of the company's core businesses.

Since its inception, DTI has introduced technologies into such businesses as construction, agriculture, medicine, defense, aerospace, and recreation.

To facilitate delivery and support of its methodologies in the manufacturing marketplace, Delphi has introduced the Delphi Center of CAD/CAM Excellence (<http://www.delphi.com/dti/dcce>). The center serves as an industry resource, providing information, training, certification, and support to manufacturers, designers, and providers of CAD/CAM training and services.