# Heavy Duty Truck Plastic Composite Door Module and Trim System

## SPE Automotive Composites Conference 2007

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**Delphi Interiors and Closures**

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# Heavy Duty Truck Plastic Composite Door Module and Trim System

## Customer Challenge

Freightliner asked Delphi to develop a modular door system to meet the following targets:

- To work within Freightliner styling theme
- Reduce cost
- Lower mass
- Meet high durability and reliability targets
- Reduce assembly labor and cost
- Produce industry leading fit and finish

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# Heavy Duty Truck Plastic Composite Door Module and Trim System

## Design Engineering Solutions to Freightliner Request

Delphi innovated a system approach to provide a low cost, low mass, high durability solution to a stringent application using single PolyPropylene resin based family of compounds

Maximum content – minimum assembly

Multifunctional hardware carrier with integrated structural, mechanical, and Class A visible trim surface

Load bearing sealed trim panel assembly

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# Heavy Duty Truck Plastic Composite Door Module and Trim System

## Delphi's Hardware Carrier and Trim Solution

Hardware module

Grab Handle

Trim module

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## Delphi's Hardware Carrier and Trim Solution

Hardware carrier is a high strength plastic injection molded component

Trim is a one piece assembly with the map pocket vibration welded to the trim to provide a sealed structural assembly.

This combination had the most potential to meet the various requirements and Incorporates:

Grab handle  with a soft touch skin
Glass, glass run channels
Belt seal
Lock latch
Window lift hardware and down-stop
Electrical components and wire harness

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## Delphi's Hardware Carrier and Trim Solution (Cont'd)

Utilized up front analysis tools DFM and DFA with first order FEA performed in the design software to develop the initial design and meet aggressive 24 month timetable

This was followed up by more in depth ADAMS and FEA analysis for static and dynamic load cases which included regulatory and customer requirements such as door slam, modal and vibration analysis for BSR together with functional lift system loads etc.

Conducted high temperature creep testing and component cycling to develop acceptance parameters for FEA analysis. (No previous data available)

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## Material Selection

Selected single resin Polypropylene based family for various components to meet the required properties :

- Low cost, low mass
- Appearance with scuff resistance
- Strength, stiffness, thermal and environmental stability
- Fast molding and easy flow
- Easy recycling

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## Material Selection

Hardware Carrier

Delphi selected a 40% short glass fiber reinforced PP material for a current hardware carrier Jointly developed with Adell Plastics.

Material developed for flow, appearance and color to meet Freightliner requirements

Trim sub-assembly

Selected 25% talc filled PP for the main trim molding and 20% glass filled PP for the vibration welded structural map pocket, balancing weldability and strength

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## Material Selection

Grab handle

Selected 30% long glass fiber filled PP substrate for the load bearing substrate and over molded TPE grained outer skin for soft touch

Speaker Grille

Selected free flowing PP material to fill the intricate perforated grille

Grille is snap fitted to carrier with features for anti rattle and distortion control.

This part is color matched with the carrier and grab handle.

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## Material Selection

Glass run channels

Selected 15% glass fiber and mineral filled PP in order to minimize warpage and meet toughness requirement

Glass run channel insert

Tri extruded section from PP, TPE and slip coat

Inside release handle seal

Molded from a TPE sub flush to the class A surface and retained by the handle bracket for good dust and air sealing, developed to meet 110,000 handle operations

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## Customer Value

Simplified customer's assembly process to reduce assembly labor time by an estimated 6 minutes

100% end of line functional testing and error proofing at sub assembly stage:

- First time quality improvement saves repair line costs in assembly plant

Reduced warranty returns and costs due to reliability improvement – made possible by thorough engineering and testing of a reduced number of components in the system

Shipped in sequence per customer assembly requirements saves approximately 1500 Square Meters plant floor space

Floor space saving based on 10 meters of line length (2 stations) by 15 meters width line including part staging (Part storage in crib not included)

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## Customer Value

Customer only deals with 1 supplier with this modular design vs 20+ different suppliers with a conventional build

Parts handling in plant

- Customer receives 5 shipped parts vs more than 15 parts per door

Estimated savings per door, over conventional design:

- Cost savings of $1.75
- Labor savings $4.80
- Total tooling cost reduction over $200,000
- Fastener count reduced to 17 from 34
- Mass reduction 2.5Kg

Cost savings estimated vs previous conventional build including trim and fastener costs
Labor estimated from reduction of 2 operators per door at 10 vehicles/hr
Tool cost reduction and mass savings estimated vs previous conventional build
Fastener count reduction actual

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## Durability and Robustness

Heavy duty usage of 1.2 M miles and 15 years life
Customer sensitivity to squeaks and rattles and durability with low frequency engine idle vibration creates some unique and aggressive performance requirements including:

High cycle Cab Shaker testing
Aggressive door slam testing
High durability window cycle testing
Operation in extreme environments
(-40 deg C to + 86 deg C, dust, humidity, salt) with minimal preventative maintenance

Structural performance requires a 300 lb vertical loading on the grab handle and map pocket and 125 lb lateral pull tests on the grab handle and inside release handle

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## Durability and Robustness (Cont'd)

Stressed features integrally molded into high strength 40% GRPP carrier such as regulator backplate, downstop, motor attachment, dog house and spring stop normally made as separate steel components successful due to use of modeling tools and advanced component creep testing with thermal cycling in the advanced PP based composite

A synthetic grease was selected to handle the high gear loading and compatibility with the steel and PP plastic based parts. This is retained in molded pocket reservoirs for lifelong service

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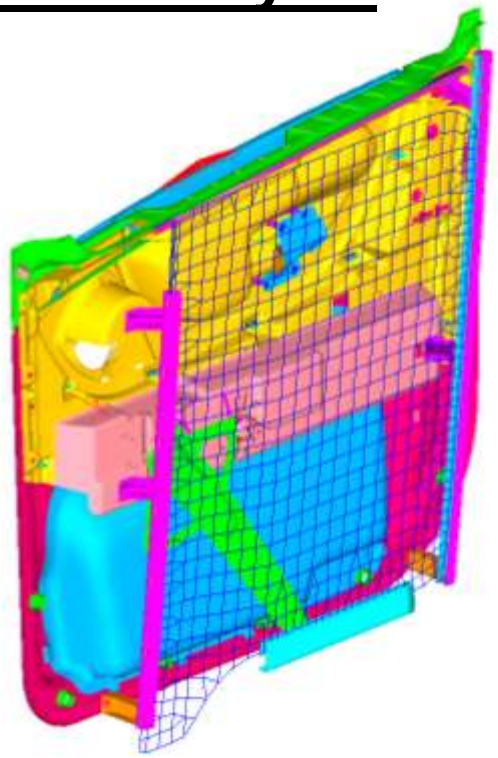
## FEA Analysis

Finite element System model



Module on a rigid fixture (grounded at mounting locations)

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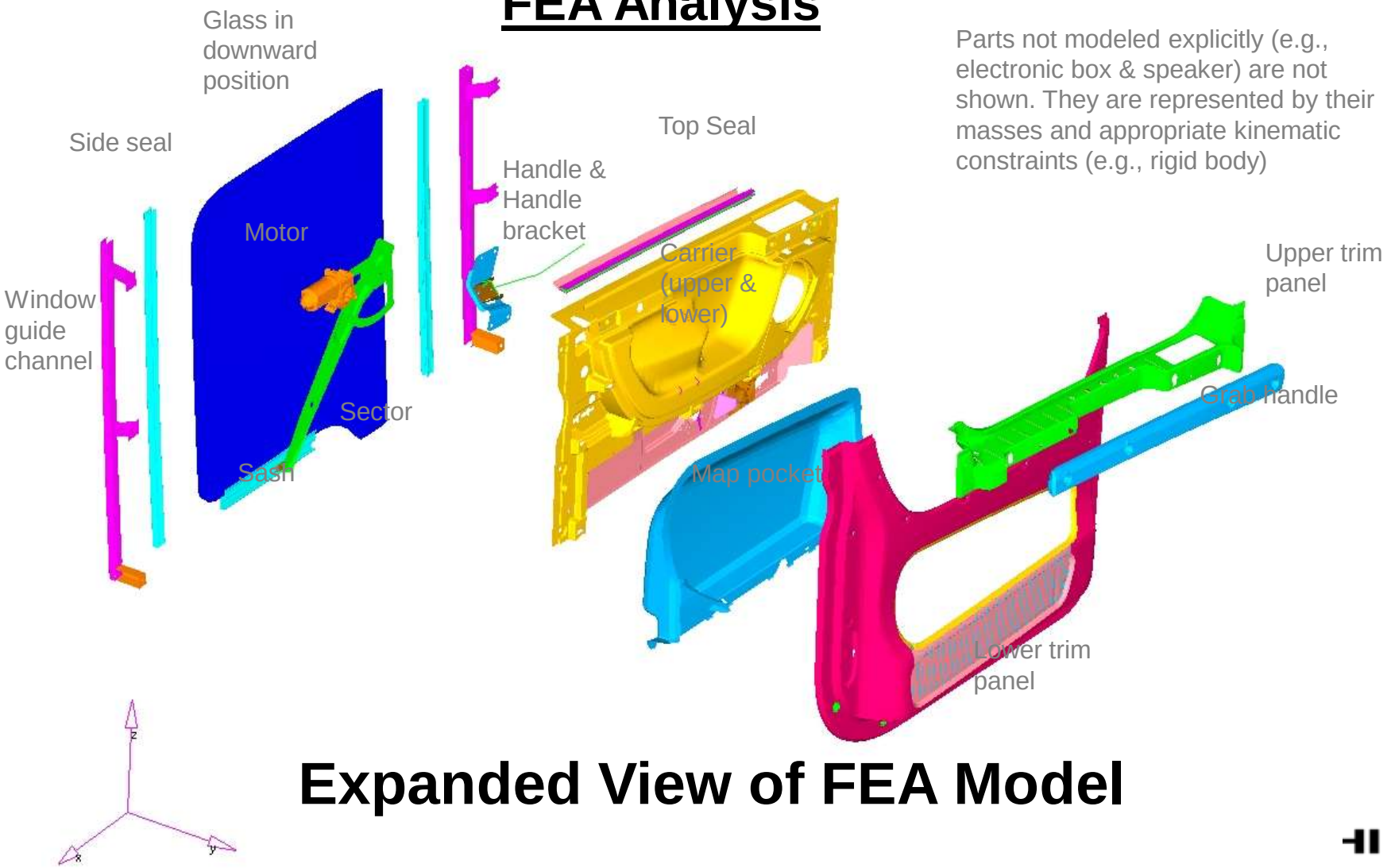
## FEA Analysis




Parts not modeled explicitly (e.g., electronic box & speaker) are not shown. They are represented by their masses and appropriate kinematic constraints (e.g., rigid body)

## Expanded View of FEA Model

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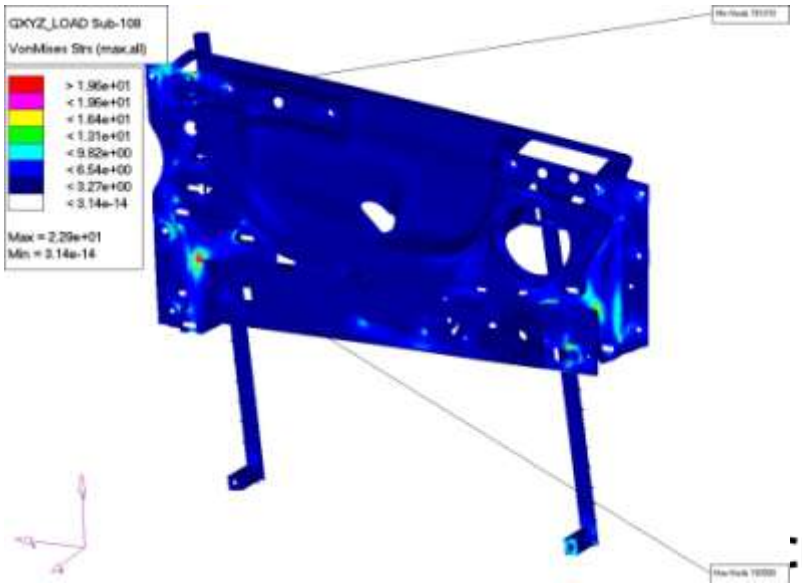
## Modal Analysis Results example

Load Case 8:  Combined XYZ gravity load

Gravity Vector = (-3.49g, -4.2g, -3.9g)

Stress Contours




Case 3

Stress contours in Carrier & Guide Channels

Max = 22.9 MPa – material yield 112Mpa

Fatigue target 36 Mpa

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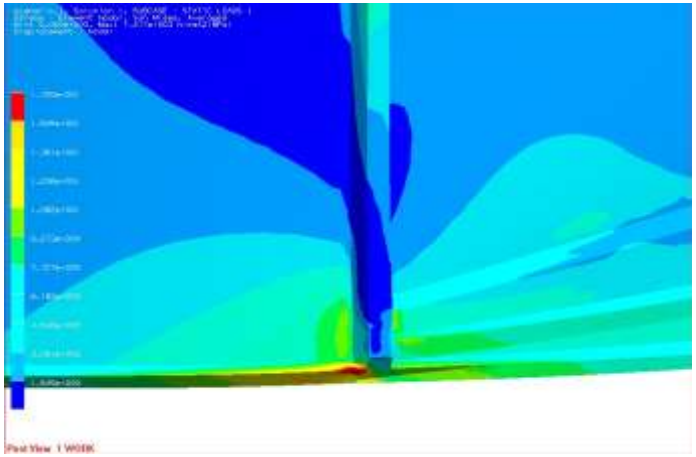
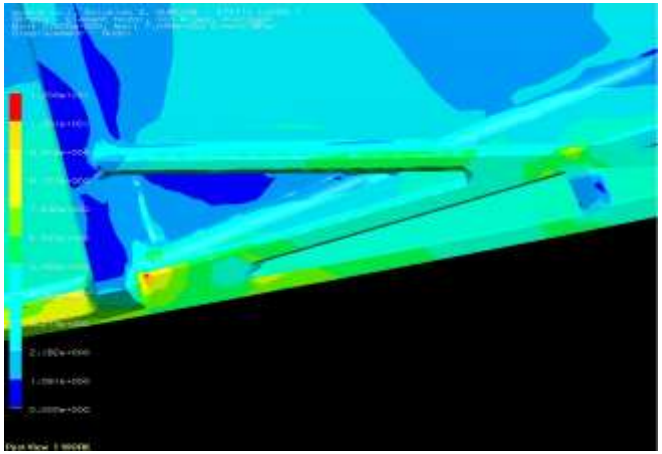
## First Order Analysis

This is one example of how we reduced the stresses caused by regulator loading via F.O.A. in the design software and design change



Carrier stress prior to design change – 17Mpa – borderline stress with fatigue and high temperature (86 deg C)



Carrier stress after design change – add rib and radii - 12 Mpa

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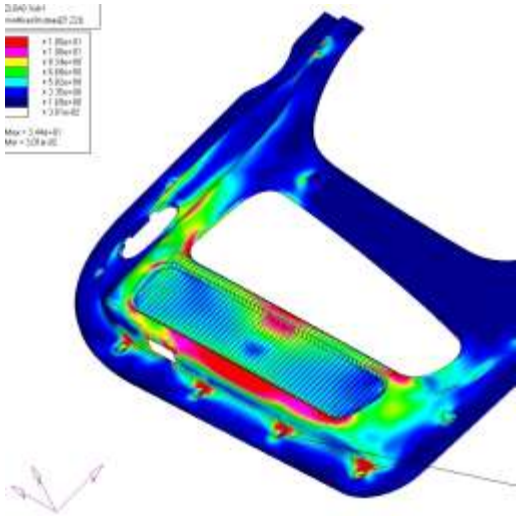
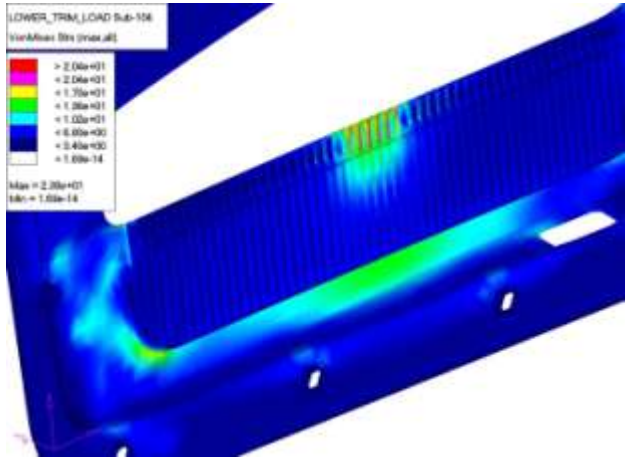
## FEA Analysis

Trim design improvement with early FEA analysis – material yield strength is 27Mpa and requirement is for a one time 300Lb vertical load. Part passed validation load test first time



Original trim panel map pocket stress under 300Lb load – 34Mpa



Revised trim panel map pocket stress under 300Lb load – 23Mpa

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## Other Features and Attributes

Spring stop, motor dog house, harness hook, trim, and speaker grille molded in die draw by use of innovative design and pass through features

Spring stop

Harness hook

Motor dog house and Down stop

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# Other Features and Attributes

Designing with tool construction considerations helped keep fastener counts low and enabled the tools to be designed without slides. Trim attachments, glass run channels and glass run channels with integrated brackets would normally be made with tool slides. These were eliminated by use of innovative design.

Trim attachment

Glass run channel attachments

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## Other Features and Attributes (Cont'd)

Mold flow analysis and sequential gating utilized to minimize warpage and manage flow lines and knit lines

Variation between components was managed using net location schemes with strategically placed molded-in locators to improve fits and minimize stack ups

Speaker Grille fit

Trim net locator

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## Other Features and Attributes (Cont'd)

Switch and wiring harness integration

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# Other Features and Attributes (Cont'd)

Integration of current production features helped manage risk with new design. (Re-used spring stop, twist lock pivot stud and basic gear designs)

Achieved water management using "shingling" of components together with the sealed map pocket and peripheral seal in the trim panel with no water sealing membrane

Designed glass lift system, and other add on parts to be serviceable though use of  snap fits and threaded fasteners

Integrated "directed buy" components into the design including the latch, speaker, express down module, inside release handle and mechanism

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## Summary

Delphi Interiors and Closures design, engineering, and material selection provided a successful solution to the customer needs with this integrated class A trim and hardware system

This case confirms the viability and value of the concept and the use of a low cost, recyclable, single family resin for other applications throughout the automotive car and truck marketplace

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## Questions?

**Thank you for your attention and interest**

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